XXXVII. *The Report of the Committee appointed by the Royal Society to consider of the best Method of adjusting the fixed Points of Thermometers; and of the precautions necessary to be used in making Experiments with those Instruments.*

Read June 19, and Dec. 28, 1777.

IT is universally agreed by all those who make and use FAHRENHEIT's thermometers, that the freezing point, or that point which the thermometer stands at when surrounded by ice or snow beginning to melt, is to be called 32°; and that the heat of boiling water is to be called 212°: but for want of further regulations concerning the manner in which this last point is to be adjusted, it is placed not less than two or three degrees higher on some thermometers, even of those made by our best artists, than on others. The two principal causes of this difference are, first, that it has never been settled at what height of the barometer this point is to be adjusted[(a)]; and

(a) FAHRENHEIT found that the heat of boiling water differed according to the height of the barometer; but supposed the difference to be much greater than

and fecondly, that fo much of the quickfilver in the thermometer as is contained in the tube, is more heated in the method ufed by fome perfons, than in that ufed by others. To fhew that this laft circumftance ought by no means to be difregarded, fuppofe that the ball of a thermometer be dipped into boiling water as far as to the freezing point, and confequently that the length of the column of quickfilver in that part of the tube which is not immerfed in the water be 180°; and fuppofe that the heat of that part of the column of quickfilver be no more than 112°. If the thermometer be now intirely immerfed in the water, the heat of this column will be increafed 100°; and confequently its length will be increafed by $\frac{100}{11500}$ parts of the whole, as quickfilver expands $\frac{1}{11500}$ part of its bulk by each degree of heat; and confequently the thermometer will ftand $\frac{180 \times 100}{11500}$ or rather more than $1^{\circ}\frac{1}{2}$ higher than it did before.

Another thing to be confidered in adjufting the boiling point is, that if the ball be immerfed deep in the water, it will be furrounded by water which will be com-

than it really is. Mr. DE LUC has fince, by a great number of experiments made at very different heights above the level of the fea, found a rule by which the difference in the boiling point, anfwering to different heights of the barometer, is determined with great exactnefs. According to this rule the alteration of the boiling point by the variation of the barometer from $29\frac{1}{2}$ to $30\frac{1}{2}$ inches is $1^{\circ}.59$ of FAHRENHEIT.

preſſed by more than the weight of the atmoſphere, and on that account will be rather hotter than it ought to be.

We are of opinion, that the quickſilver in the tube ought, if poſſible, to be kept of the ſame heat as that in the ball, and that the ball ought not to be immerſed deep in the water. Theſe two requiſites may be obtained by uſing a veſſel covered ſo as to allow no more paſſage than what is ſufficient for carrying off the ſteam; for then, if the thermometer be incloſed in this veſſel in ſuch manner that the boiling point ſhall riſe but a little way above the cover, almoſt all the quickſilver in the tube will be ſurrounded by the ſteam of the boiling water, and conſequently will be nearly of the ſame heat as the water itſelf: we therefore made ſome experiments to determine how regular the boiling point would be when tried in ſuch veſſels, both when the ball was immerſed in the water, and when it was expoſed only to the ſteam as recommended by Mr. CAVENDISH [(b)]

The veſſel uſed in theſe experiments is repreſented in fig. 1. AB*ba* is the pot containing the boiling water; D*d* is the cover; E is a chimney for carrying off the ſteam; M*m* is the thermometer faſtened to a braſs frame; this thermometer is paſſed through a hole F*f* in the cover, and reſts thereon by a circular braſs plate G*g* faſtened

(*b*) Phil. Tranſ. vol. LXVI. p. 380.

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to its frame, a piece of woollen cloth being placed between G*g* and the cover, the better to prevent the escape of the vapours.

There were two pots of this kind used by us; one five inches in diameter and nine deep; the other, $4\frac{1}{4}$ in diameter and 23 deep. Two of the thermometers principally used were the short ones, the brass plate (G*g*) being placed only $3\frac{3}{4}$ inches above the top of the ball, and the boiling point rising not much above that plate: the third thermometer was much longer, the plate (G*g*) being 17 inches above the ball. They were all three quick; the first containing only $2\frac{1}{2}$ degrees to an inch; the second 5°; and the third 10°. The first had a cylinder instead of a ball $1\frac{1}{2}$ inch long and $\frac{4}{10}$ in diameter[(c)]; the two others had spherical balls, about $\frac{3}{4}$ of an inch in diameter.

On trying these thermometers in the above mentioned vessels, with the water rising two or three inches above the top of the ball, we found some variations in the height according to the different manner of making the experiment, but not very considerable; for the most part there was very little difference whether the water boiled

(*c*) In the two short thermometers the quicksilver would have descended into the ball when cold, had not the tube been swelled a little, close to the ball, in order to prevent it.

 fast

faſt or very gently; and what difference there was, was not always the ſame way, as the thermometer ſometimes ſtood higher when the water boiled faſt, and ſometimes lower. The difference, however, ſeldom amounted to more than $\frac{1}{10}$th of a degree, unleſs a conſiderable part of the ſides of the pot were expoſed to the fire; but in ſome trials which we made with the ſhort thermometers in the ſhort pot, with near four inches of the ſide of the veſſel expoſed to the fire(d), they conſtantly ſtood lower when the water boiled faſt than when ſlow, and the height was in general greater than when only the bottom of the pot was expoſed to the fire. This difference however was not perceived in the trials of the long thermometer in the deep pot, as there ſeemed very little difference in the height whether the water boiled faſt or ſlow, or whether more or leſs of the ſide of the pot was expoſed to the fire. The greateſt difference obſerved in the ſame thermometer, on the ſame day and in the ſame water, according to the different manner of trying the experiment, was half a degree.

(*d*) In all our experiments, the water was boiled over a portable black-lead furnace, covered with an iron plate, which had a hole cut in it juſt big enough to receive the bottom of the pot; ſo that, by paſſing the bottom through this hole to a greater or leſs depth, we could expoſe more or leſs of the ſides to the fire. In the other experiments, not more than one inch of the ſides was ever expoſed to the fire.

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We made some trials with the long thermometer in the deep pot, to determine how much the height of the boiling point was affected by a greater or less depth of water above the ball. By a mean of the experiments it stood ,66 of a degree higher when the water rose 15 inches above the ball, than when it was only three inches above the ball; so that increasing the depth of water above the ball by 11 inches, raised the thermometer ,66 of a degree, that is ,06 for each inch.

We would by no means infer however from hence, that it is a constant rule, that the height of the boiling point is increased ,06 of a degree by the addition of each inch in the depth of the water above the ball; as perhaps the proportion would be found very different in greater depths of water or in wider vessels.

If this rule is constant, it would shew that, when the pressure on that part of the water which surrounds the ball is increased by increasing the depth of water above the ball, the height of the boiling point is not altered thereby more than half as much as by an equal increase of pressure produced by an alteration in the weight of the atmosphere: for the pressure on that part of the water which surrounds the ball is as much increased by an alteration of 11 inches in the depth of the water above the ball, as by an increase of $\frac{11}{13\frac{1}{2}}$ of an inch in the height

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of the barometer; and ſuch an alteration in the height of the barometer is ſufficient to raiſe the boiling point 1°,3.

It ſeems as if the height of the boiling point was in ſome meaſure increaſed by having a great depth of water below the ball, as in general the ſhort thermometers ſtood higher when tried in the deep pot than in the ſhort one; this effect, however, did not always take place. In the former of theſe caſes, the depth of water below the ball was about 18 inches, in the other only 4; but the depth of water above the ball was the ſame in both caſes.

It muſt be obſerved, that when there was a great depth of water in the veſſel, either above or below the ball, the experiments were much more irregular, and the quickſilver in the tube remained much leſs ſteady than when it was ſmall. When the depth of water in the veſſel is great, it is apt to boil in guſts, which ſeems to be the cauſe of this irregularity; though we could not perceive any regular connection between theſe guſts and the riſing of the thermometer.

In the experiments made with the water not riſing ſo high as the ball, ſo that the thermometer was expoſed only to the ſteam, we very ſeldom found any ſenſible difference whether the water boiled faſt or ſlow: but whenever

whenever there was any, the greater height was when the water boiled fast; the difference, however, never amounted to more than $\frac{1}{20}$th of a degree.

There was scarce ever any sensible difference whether the short thermometers were tried in the short pot or the deep one, though in the former case the ball was raised very little above the surface of the water, and in the latter not less than 14 inches: neither did we find any sensible difference in trying them in the tall pot, whether there was a greater or less depth of water in the vessel.

As it was nevertheless suspected, that the heat of the steam might possibly be less near the top of the pot than lower down (for in these experiments the ball of the thermometer was always at the same depth below the cover, though its height above the surface of the water was very different) we made two holes in the side of a pot four inches deeper than the deepest of the foregoing, one near the top of the pot, and the other not far from the bottom, and passed the ball of the thermometer through one or the other of these holes, taking care to stop up both holes very carefully, so that no air could enter into the pot by them: no sensible difference could be perceived in the height, whether the thermometer was placed in the upper or lower hole, though in one

case the ball was only three inches, and in the other 21 inches, below the cover.

The heat of the steam therefore appears to be not sensibly different in different parts of the same pot; neither does there appear to be any sensible difference in its heat, whether the water boil fast or slow; whether there be a greater or less depth of water in the pot; or whether there be a greater or less distance between the surface of the water and the top of the pot; so that the height of a thermometer tried in steam, in vessels properly closed, seems to be scarce sensibly affected by the different manner of trying the experiment.

Though, as was before said, there was scarce any difference in the height of the quicksilver, whether the water boiled fast or slow, yet, when the water boiled slow, the thermometer was a great while before it rose to its proper height; and when it boiled very slow, it seemed doubtful whether it would have ever risen to it, especially if the ball was raised a great way above the surface of the water: but when, by making the water boil briskly, the thermometer had once risen to its proper height, the water might then be suffered to boil very gently, even for a great length of time, without the thermometer sinking sensibly lower[(e)].

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(e) The reason of this seems to be that, while any air is left in the pot, the steam

All three thermometers were found to ſtand, in general, from 30 to 65 hundredths of a degree higher when the ball was immerſed a little way in the water (neglecting thoſe obſervations in which much of the ſides of the pot were expoſed to the fire) than when it was tried in ſteam: at a medium they ſtood $\frac{48}{100}$ higher, which is equal to the difference produced by a variation of $\frac{3}{10}$ths of an inch in the barometer; ſo that the boiling point, adjuſted at a given height of the barometer, with the ball immerſed a little way in the water, will in general agree with that adjuſted in ſteam, when the barometer is $\frac{3}{10}$ths of an inch higher.

It muſt be obſerved, that in all theſe experiments a piece of flat tin plate was laid looſely on the mouth of the chimney E, ſo as to leave no more paſſage for the ſteam than what was ſufficient to prevent the tin plate from being lifted up. In trying the thermometers in ſteam, this is by no means unneceſſary; for, if the cover of the pot does not fit pretty cloſe, the thermometers will immediately ſink ſeveral degrees on removing the tin plate; but, when their balls are immerſed in the water, the removal of the tin plate has no ſenſible effect.

ſteam cannot acquire its full degree of heat; and that when the water boils very gently, the air is not eaſily intirely expelled from the pot. That the ſteam will not acquire its full degree of heat while any air is left in the pot will appear from the next paragraph but one.

If this cover to the chimney had been heavy, the included ſteam might have been ſo much compreſſed thereby, that the water and ſteam might have acquired a conſiderably greater heat than they ought to have done; but as this plate lay looſe on the chimney, and as its weight was not greater than that of a column of quickſilver, whoſe baſe is equal to that of the mouth of the chimney, and whoſe altitude is $\frac{1}{50}$th of an inch, the exceſs of the compreſſion of the included ſteam above that which it would ſuffer in an open veſſel, could not be greater than that which would be cauſed by an increaſe of $\frac{1}{50}$th of an inch in the height of the barometer, which is too ſmall to be worth taking notice of; for, if the exceſs of compreſſion was greater than that, the tin plate muſt neceſſarily be lifted up ſo much as to afford a ſufficient paſſage for the ſteam to eſcape faſt enough, though urged by no greater force than that.

Though in the different trials of the ſame thermometer in ſteam, on the ſame day, and with the ſame water, ſo little difference was obſerved, according to the different manner of trying the experiment; yet there was a very ſenſible difference between the trials made on different days, even when reduced to the ſame height of the barometer, though the obſervations were always made either with rain or diſtilled water. The difference,

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however, never amounted to more than a quarter of a degree, except in one thermometer, in which there were three obſervations out of eighteen which differed more than that; one of them differed ſo much as 0.65° from ſome of the reſt. In the obſervations made with the ball immerſed a little way in the water, there was a greater difference between the obſervations of different days, even neglecting thoſe in which much of the ſides of the pot were expoſed to the fire. In two of the thermometers the different obſervations differed about $\frac{35}{100}$ of a degree from each other; but in the other thermometer they varied $\frac{8}{10}$ths.

We do not at all know what this difference could be owing to, eſpecially in the obſervations in ſteam. It could not proceed intirely from ſome unknown difference in the water; for, if it did, the difference between the different thermometers ſhould have been always the ſame, which was not the caſe, though in general, on thoſe days in which one thermometer ſtood high, the others did alſo, eſpecially in the trials in ſteam. Moreover, as far as can be perceived from our experiments, there ſeems to be very little difference between different waters with reſpect to the heat which they acquire in boiling. We could not be ſure that there was any difference between rain or diſtilled water and pump water, provided

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the latter had boiled long: neither did any difference ſeem to ariſe from the water containing ſuch ſubſtances as are diſpoſed to part readily with their phlogiſton; for, on trying the thermometers in the ſteam of diſtilled water, their height was not ſenſibly altered by pouring in a ſmall quantity of a ſolution of liver of ſulphur, or of iron filings imperfectly ruſted. The thermometer, however, ſeemed to ſtand ſenſibly lower in pump water beginning to boil, than in the ſame water long boiled, but the difference ſcarcely exceeded $\frac{1}{10}$th or $\frac{1}{5}$th of a degree.

We made ſome experiments to determine the heat of water boiling in open veſſels. In general, when the veſſel was almoſt full, and the water boiled faſt, and the ball of the thermometer was held from three-quarters to two or three inches under water, and alſo in that part of the veſſel where the current of water aſcended upwards, that is, in the hotteſt part of the water, its heat was not much different from that of the ſteam of water boiling in cloſed veſſels, varying only from a quarter of a degree more than that, to as much leſs; but if the water boiled gently, its heat would frequently be half or three-quarters of a degree cooler than the ſteam. If the experiment was tried in the deep pot with ſuch a quantity of water in it that the ſurface was at leaſt 14 or 15 inches below the top of the pot, ſo that though the veſſel was open,

open, yet the water was not much expofed to the air, its heat then feemed fcarcely lefs than when boiled in clofed veffels.

In making thefe experiments we chiefly made ufe of the two fhort thermometers, in which, as the quantity of quickfilver contained in the tube was fmall, the error arifing from that part of the quickfilver being not heated equally with that in the ball, could be but fmall: for example, in the fecond of the fhort thermometers, the number of degrees contained in that part of the tube between the circular plate G*g* and the ball was 18°. In the experiments in fteam this part of the tube was heated to the fame degree as the ball. Suppofe now, that in open veffels it was heated only to 122°, or was 90° cooler than the ball, it is plain, that the thermometer would ftand only $\frac{18 \times 90}{11500}$, or $\frac{1}{7}$th of a degree lower than it did in fteam, provided the heat of the quickfilver in the ball was the fame in both cafes. In the other fhort thermometer, as there were only half as many degrees to an inch, the error was only half as great.

In feveral of the experiments, however, we made ufe of the long thermometer; but then it was neceffary to make an allowance on account of the quickfilver in the tube being not heated equally with that in the ball. The

better

better to enable us to do this, we made uſe of a thermometer tube, filled with quickſilver in the ſame manner as a thermometer, only without any ball to it, or a thermometer without a ball, as we may call it. A ſmall braſs plate was fixed to the tube near the top of the column of quickſilver, to ſhew the heat as in a common thermometer. In all our experiments with the long thermometer in open veſſels, this tube without a ball, was placed by its ſide; whence, as the quickſilver in the tube of the long thermometer could hardly fail of being nearly of the ſame heat as that in the tube without a ball, we knew pretty nearly the heat of the quickſilver in the tube of the former, and conſequently how much higher it would have ſtood if the quickſilver in its tube had been of the ſame heat as that in the ball. For example, on October 19, the long thermometer tried in an open veſſel, the water boiling faſt, ſtood 1°.65 lower than it did when tried in ſteam the ſame day, the quickſilver in the tube without a ball ſtanding at the ſame time at 109°: we may therefore conclude, that the heat of the quickſilver, in that part of the tube of the long thermometer which was not immerſed in the water, was alſo 109°; and conſequently, as that part of the tube contained about 170°, the thermometer ſtood $\frac{170 \times 103}{11500}$, or

1°52

1°.52 lower than it would have done if the quickſilver in the tube had been of the ſame heat as that in the ball; and, conſequently, the quickſilver in the ball of the thermometer was in reality .07 cooler than when tried in ſteam.

We examined the boiling points of ſeveral thermometers, made by different artiſts, by trying them in ſteam when the barometer was at 30.1, and finding what diviſion on the ſcale the quickſilver ſtood at. The difference of the extremes was $3^{\circ}\frac{1}{4}$; but, by a mean of all, it was found to ſtand at 213°.1, and conſequently would have ſtood at 212°, if the barometer had been at 29.4; ſo that if the boiling point was to be adjuſted, either in ſteam, when the barometer is at 29.4, or with the ball immerſed two or three inches in water, when the barometer is at 29.1, it would agree beſt with the mean of the abovementioned thermometers. But as it ſeems to be of no great ſignification to make the boiling point agree very nearly with the mean of the thermometers made at preſent, when the extremes differ ſo widely; and as we apprehend that it will be more convenient to the makers that ſome height ſhould be choſen which differs leſs from the mean, as thereby they will more frequently have an opportunity of adjuſting the boiling point without the trouble and danger of miſtakes which attend the

making

making a correction, we recommend, that the boiling point should be adjusted when the barometer is at 29.8, if the person chuses to do it in steam; or when the barometer is at $29\frac{1}{2}$, if he chooses to do it in close vessels, with the ball immersed to a small depth under the water. Our reason for pitching upon this precise height is, that thereby the boiling point will differ from Mr. DE LUC's boiling point, by a simple fraction of the degrees of his common scale, namely three-quarters of a degree higher.

We are informed by Mr. DE LUC, that the method he used in adjusting the boiling point, though he forgot to mention it in the *Récherches sur les Modifications de l'Atmosphère*, was to wrap rags round the tube of the thermometer, and to try it with the ball immersed in water in an open vessel, of the form described in the abovementioned book, while boiling water was poured at different times on the rags, in order that the quicksilver in the tube might be heated, if possible, to the same degree as that in the ball. As well as we can judge from the abovementioned experiments in open vessels, and from the few trials we have made of this method, we are inclined to think, that the boiling point adjusted this way will in general differ but little from that adjusted in steam at the same height of the barometer, especially if the thermometer be not very long, and do not extend a great

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way below the freezing point[(f)]; consequently, as Mr. DE LUC's boiling point was adjusted when the barometer was at 27 Paris or 28.75 English inches, it will stand lower than that adjusted in the manner recommended by us, by three-quarters of a degree of his scale; or 80°$\frac{3}{4}$ on DE LUC's thermometer, will answer to 212° on FAHRENHEIT's adjusted in the manner proposed.

Though the boiling point be placed so much higher on some of the thermometers now made than on others, yet we would not have the reader think that this can make any considerable error in the observations of the weather, at least in this climate; for an error of 1°$\frac{1}{2}$ in the position of the boiling point will make an error of only half a degree in the position of 92°, and of not more than a quarter of a degree in the point of 62°. It is only in nice experiments, or in trying the heat of hot liquors, that this error in the boiling point can be of much signification.

(f) In order to see how much the quicksilver in the tube of the thermometer would be heated in this method of adjusting the boiling point, we took the abovementioned tube without a ball, wrapped it round with rags, and poured boiling water on it as above described: the heat of the quicksilver therein was found to be about 21° less than that of boiling water; and, therefore, the boiling point of a thermometer, adjusted in this manner, supposing the thermometer to be dipped into the water as far as to the point of 32°, should stand about one-third of a degree lower than it would do if the quicksilver in the tube was heated equally with that in the ball.

There is another circumſtance that we have not yet taken notice of, which, in ſtrictneſs, cauſes ſome error in thermometers, namely, the difference of expanſion of the glaſs tube and the ſcale. But this error is in almoſt all caſes ſo ſmall as to be not worth regarding; we have, however, in the note below given a rule for computing the value of it [g].

(*g*) The uſual way of adjuſting thermometers is, to mark the boiling and freezing points on the glaſs tube, and not to ſet off thoſe points on the ſcale till ſome time after, when the tube and ſcale may both be ſuppoſed to be nearly of the temper of the air in the room; conſequently, when the thermometer is expoſed to a greater heat than that, the ſcale, if of braſs, will expand more than the glaſs tube, and the diviſions on it will be longer than they ought to be; but, if the ſcale be of wood, it will expand leſs than the glaſs tube, and the diviſions will be too ſhort. Let now the heat of the air, when the diviſions were ſet off on the ſcale, be called A; let the degree of heat which the thermometer ſtands at in the experiment be called D; and let the degree anſwering to that point of the ſcale in which the thermometer is faſtened to the ſcale be called F. Then, if all parts of the thermometer and ſcale are heated equally, and the ſcale is of braſs, the thermometer will appear to ſtand lower than it ought to do by the $\frac{\overline{D-F} \times \overline{D-A}}{165000}$ part of a degree, obſerving, that if $\overline{D-F} \times \overline{D-A}$ is negative, it will ſtand higher than it ought to do; but if the ſcale is of wood, it will ſtand higher than it ought to do by the $\frac{\overline{D-F} \times \overline{D-A}}{216000}$ part of a degree. If the thermometer be faſtened to the ſcale by the ball, or any part of the tube lower than the obſerved heat, the error will be the ſame, whether that part of the tube and ſcale, which is above the obſerved degree, be of the ſame heat as the ball or not: but if the thermometer is faſtened to the ſcale by the top of the tube, as is frequently done, then the error will vaniſh whenever that part of the tube and ſcale, which is above the obſerved degree, is not much heated. This rule is founded on Mr. SMEATON's experiments, who found, that white glaſs expands $\frac{1}{100}$th of an inch in a foot by 180° of heat; that braſs wire expands $\frac{232}{10000}$; and that wood expands ſcarce ſenſibly.

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In making experiments with thermometers, it evidently is equally neceſſary that the quickſilver in the tube ſhould be of the ſame heat as that in the ball, as it is in adjuſting the boiling point: for this reaſon, in trying the heat of liquors much hotter or colder than the air, the thermometer ought, if poſſible, to be immerſed as far as to the top of the column of quickſilver in the tube. As this, however, would often be very difficult to execute, the obſerver will frequently be obliged to content himſelf with immerſing it to a much leſs depth. But then as the quickſilver, in a great part of the tube, will be of a different heat from that in the ball, it will be neceſſary, where any degree of accuracy is required, to make a correction, on that account, to the heat ſhewn by the thermometer. If the heat of the quickſilver in the tube be known, the correction may readily be made by help of the annexed table; the only difficulty lies in eſtimating what that heat may be. In all probability the heat of the quickſilver in the tube will not be very different from that of the air which ſurrounds it[(b)]; but as that

(*b*) This muſt evidently be the caſe, unleſs the quickſilver in the tube is conſiderably heated by its contact with that in the ball. To ſee whether this was the caſe, ſome ſand was heated in a ſmall copper diſh over a lamp to the heat of about 212°, and the abovementioned tube, without a ball, laid horizontal with the end extending about half an inch over the ſand; but, to prevent its being heated thereby, a piece of wood, about a quarter of an inch thick, was

that air will be affected by the ſteam of the liquor, and the fire by which it is heated, it will commonly be of a very different heat from the reſt of the air of the room in which the experiment is made; but as no great nicety is required in eſtimating the heat of the quickſilver in the tube, inſomuch that a miſtake of 25° therein will cauſe an error of only half a degree in the correction, when the number of degrees in that part of the tube which is not immerſed in the liquor is not more than 220°, it will commonly be not difficult to gueſs at the heat of the quickſilver in the tube as near as is required(i). But if the obſerver is deſirous of more accuracy,

was laid between the ſand and it. After it had remained a ſufficient time in this ſituation, the diviſion which the quickſilver ſtood at was obſerved. The piece of wood was then removed, and the end of the tube laid in the ſand, which was heaped over it ſo that about half an inch of the column of quickſilver was intirely ſurrounded by the hot ſand, and muſt therefore be heated to nearly the ſame degree as it. The quickſilver in the tube roſe very little higher than before, and ſeemingly not more than might be owing to the expanſion of the half inch of quickſilver which was ſurrounded by the ſand; ſo that it ſhould ſeem, that heating one end of the column of quickſilver does not communicate much heat to the reſt of the column; and conſequently, that, when the ball of a thermometer is immerſed in hot liquor, the quickſilver in the tube will not be much hotter than the ſurrounding air.

(i) The better to enable the reader to gueſs at the heat of the quickſilver in the tube, in caſes of this kind, we tried how much the quickſilver in the above-mentioned tube, without a ball, would be heated when held over a veſſel of boiling water. It is true, that theſe experiments cannot be of any great ſervice towards this purpoſe, as the tubes will be very differently heated, according to the

racy, he may find the heat of the ſurrounding air by holding the ball of a ſmall thermometer near the tube of

the degree of heat of the fluid, and the quantity of ſteam which it furniſhes, and according to the nature of the fire by which it is heated; yet as the experiments may perhaps ſerve in ſome meaſure to rectify our ideas on this head, we will give the reſult. When the abovementioned tube without a ball *, the length of the column of quickſilver in which was 15 inches, was held perpendicularly over the veſſel of boiling water, with its bottom even with the ſurface of the water, the heat of the quickſilver was in all the trials we made from 68 to 28° hotter than the air of the room. If the tube was held inclined to the horizon, in an angle of about 30°, with the bottom of the column of quickſilver reaching not more than three quarters of an inch within the circumference of the pot, ſo that the column of quickſilver was as little heated by the ſteam as could eaſily be done, it was from 30 to 7° hotter than the air. When a ſhorter tube of the ſame kind, in which the column of quickſilver was ſeven inches, was uſed, the quickſilver was from 62 to 44° hotter than the air, when held perpendicularly, and from 49 to 36° hotter when held inclined. The water in theſe trials frequently boiled pretty faſt, but never very violently. It was in general heated over a portable black lead furnace placed in the middle of the room; but it was once heated over an ordinary chafing-diſh, when the quickſilver in the long tube, held perpendicularly, was found to be 64° hotter than the air, When the experiments were tried without doors, the heat of the quickſilver in the tube would vary very much, according as the wind blew the ſteam and hot air from or towards the tube, but it ſometimes roſe as high as it did within doors.

The moſt convenient method we know of making theſe tubes without a ball is, to fill a thermometer in the uſual manner, and heat the ball till there is a proper quantity of quickſilver in the tube, and then to make the column of quickſilver ſeparate at the neck of the ball, and run to the extremity of the tube, ſo as to leave a vacuum between the ball and the column of quickſilver, as is expreſſed in fig. 2. where the ſhaded part AD repreſents the column of quickſilver, and BA that part in which there is a vacuum. The tube muſt then be ſealed ſome-

* See p. 830. l. 1.

where

of the thermometer with which he tries the heat of the liquor; or, what will be much better, he may have a tube without a ball, ſuch as is above deſcribed, faſtened to the frame of the thermometer, on one ſide of the tube; or if he has two ſuch tubes, of different lengths, it will be ſtill more accurate.

To avoid the inconvenience of this correction, perhaps it may be thought, that both in adjuſting the boiling point and in trying the heat of liquors, it would be better that not much more than the ball of the thermometer ſhould be immerſed, and that the tube ſhould be held inclined in ſuch manner as to be heated as little as poſſible; as it may be ſaid, that by this means you will find the heat of liquors pretty nearly, without the trouble of making any correction; and that, though in ſtrictneſs a correction would be required in obſerving the heat of the air with

where between B and A as at E, and cut off there; after which it muſt be held with the end D upwards, ſo as to make the column of quickſilver run to the extremity E: by this method of filling it is plain, that no ſenſible quantity of air can be left between E and the column of quickſilver; but yet the quickſilver will be apt not to run ſufficiently cloſe to the extremity E, as the weight of the column will be ſcarcely ſufficient to force it into the narrow ſpace which will commonly be left in ſealing the tube, eſpecially when held nearly horizontal: for this reaſon it will be proper to open the tube at D, ſo as to let in the air, and then ſeal it again. It muſt be obſerved, that the ſpace left between D and the column of quickſilver ought not to be leſs than the tenth part of the length of the column of quickſilver, as otherwiſe the included air might be too much compreſſed by the expanſion of the quickſilver when much heated.

ſuch

ſuch thermometers, yet the heat of the atmoſphere never differs ſo much from the mean heat, as to make that correction of much conſequence[k]. But, on the other hand, this method of making and uſing thermometers is much leſs exact than the former, and therefore is unfit for nice experiments; and, beſides, a correction would be as neceſſary with this kind of thermometer in trying the heat of air, artificially heated, or in finding the heat of large quantities of hot liquors, in which it would be difficult to prevent the quickſilver in the tube from being heated

(*k*) The degrees on all thermometers are intended to anſwer to equal portions of the ſolid contents of the tube; and, conſequently, if the quickſilver in the tube is kept conſtantly of the ſame heat as that in the ball, the degrees will anſwer to equal increments of bulk of the whole quantity of quickſilver in the thermometer, that is of a given weight of quickſilver. But if only the quickſilver in the ball is heated, and that in the tube is kept always of the ſame heat, the degrees will anſwer to equal increments of a given bulk of quickſilver; ſo that the ſcale of the thermometers will be really different in theſe two methods of proceeding, and in high degrees the difference will be very conſiderable: for example, let two thermometers be made, and in the firſt of them let care be taken, both in adjuſting the fixed points and in trying the heat of liquors, that the quickſilver in the tube ſhall be of the ſame heat as that in the ball; and in adjuſting the fixed points of the ſecond, and in trying the heat of liquors with it, let care be taken that the quickſilver in the tube ſhall remain always of the ſame invariable heat, and let the freezing and boiling points be marked 32 and 212 on both of them: then will the degree of 620 on the firſt anſwer to that of 600 on the ſecond; that of 406 to 400; that of 302 to 300; and that of 119.7 to 120; that is, a liquor which appears to be of 620° of heat by the firſt will appear to be of 600 by the ſecond, &c. It appears from hence, that it would be improper to employ the latter method of adjuſting and uſing thermometers for ordinary purpoſes, and the former for nice experiments.

by the ſteam, as it is in finding the heat of liquors with the other thermometer, whenever the ball is not immerſed to a ſufficient depth; ſo that, on the whole, the former method of making and uſing thermometers ſeems much the beſt.

A much better way of avoiding the trouble of making a correction would be to have two ſets of diviſions made to ſuch thermometers as are intended for trying the heat of liquors; one of which ſhould be uſed when the tube is immerſed almoſt to the top of the column of quickſilver; and the other, when not much more than the ball is immerſed, in which laſt caſe the obſerver ſhould be careful that the tube ſhould be as little heated by the ſteam of the liquor as conveniently can be. It is difficult to give rules for conſtructing this ſecond ſet of diviſions, as the heat of the quickſilver in the tube will be very different according to the temper of the air in the room, the quantity and nature of the fluid whoſe heat is to be tried, the manner in which it is heated, and the other circumſtances of the experiment; but, on the whole, we think that, given in the following table, would be as proper as any.

	Degree anſwering to that point of the tube which is two inches above the ball.										
	+75	+50	+25	0	—50	—100	—200	—300	—400	—500	
—500										—500	0
—400									—400	—396.5	0
—300								—300	—297.4	—294.8	0
—250								—248.9	—246.7	—244.6	0
—200							—200.	—198.3	—196.5	—194.8	0
—150							—149.3	—148.	—146.7	—145.4	0
—100						—100	— 98.9	— 97.7	— 96.6	— 95.5	30
— 50					—50	—49.7	— 49.	— 48.3	— 47.6	— 46.9	30
0				0	+0.2	+0.3	+ 0.6	+ 0.9	+ 1.2	+ 1.5	35
+150	149.5	149.4	149.	148.7	148.4	147.3					75
+200	198.8	198.5	198.3	198.	197.5	197.					85
+250	247.5	247.1	246.8	246.4	245.7						85
+300	295.8	295.3	294.9	294.4	293.4						85
+350	343.7	343.1	342.5	342.							85
+400	391.1	390.4	389.7	389.1							85
+450	438.1	437.3	436.5	435.7							85
+500	484.7	483.8	482.9	482.							85
+600	576.5	575.4	574.3	573.2							85

To make uſe of this table, ſeek in the uppermoſt horizontal line the degree of the thermometer anſwering to that point of the tube which is two inches above the ball; and in the left-hand column ſeek the degrees of the ſecond ſet of diviſions; the correſponding numbers in the table are the correſponding degrees of the firſt ſet, or the degrees which they muſt be ſet oppoſite to. The right-hand perpendicular column ſhews the heat which the quickſilver in the tube was ſuppoſed to be of in forming this table.

Though this ſecond ſet of diviſions be far from accurate, yet it is at leaſt as much ſo as a thermometer adjuſted in the latter method can be; ſo that this double ſet of diviſions poſſeſſes all the advantages which can be expected from that method of adjuſting thermometers, without the inconveniences.

A table for correcting the obferved height of a thermometer, whenever the quickfilver in the tube is not of the fame heat as that in the ball.

Diff. of Heat	Degrees not immerfed in the liquors.														
	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750
50	.2	.4	.7	.9	1.1	1.3	1.5	1.7	2.	2.2	2 4	2.6	2.8	3.1	3.3
100	.4	.9	1.3	1.8	2.2	2.6	3.0	3.5	3.9	4.4	4.8	5.2	5.7	6.1	6.6
150	.7	1.3	2.0	2.6	3.3	3.8	4.6	5.2	5.9	6.5	7.2	7.9	8.4	9.2	9.8
200	.9	1.8	2.6	3.5	4.4	5.1	6.1	7.0	7.8	8.7	9.6	10	11	12	13
250	1.1	2.2	3.3	4.4	5.5	6.4	7.6	8.7	9.8	11	12	13	14	15	16
300	1.3	2.6	3.8	5.1	6.4	7.7	9.1	10	12	13	14	16	17	18	20
350	1.5	3.0	4.6	6.1	7.6	9.1	11	12	14	15	17	18	20	21	23
400	1.7	3.5	5.2	7.0	8.7	10	12	14	16	17	19	21	23	24	26
450	2.	3.9	5.9	7.8	9.8	12	14	16	18	20	22	24	25	27	29
500	2.2	4.4	6.5	8.7	11	13	15	17	20	22	24	26	28	31	33
550	2.4	4.8	7.2	9.6	12	14	17	19	22	24	26	29	31	34	36

To make ufe of this table, in the left-hand perpendicular column look for the number of degrees contained in that part of the tube which is not immerfed in the fluid whofe heat is to be tried, and in the upper horizontal line feek the fuppofed difference of heat of the quickfilver in that part of the tube from that in the ball; the correfponding number in the table is the correction, which muft be added to the obferved heat when the

 quick-

quickſilver in the tube is cooler than that in the ball, and ſubtracted when it is warmer: for example, let the obſerved heat of the fluid be 475°, let the thermometer be immerſed in the fluid as far as to the degree of 25°, or to that part of the tube which ſhould be marked 25° if the diviſions were continued long enough; then is the number of degrees in that part of the tube which is not immerſed in the fluid 450; and let the heat of the quickſilver in that part of the tube be ſuppoſed 100°; and conſequently, the difference of heat of the quickſilver in that part of the tube from that in the ball 375; then in the left-hand perpendicular column ſeek the number 450, and in the upper horizontal line the number 375; the correſponding number in the table, or the correction, is 15°, and therefore the true heat of the fluid is 490°.

This correction may be had very eaſily without the help of the table, only by multiplying the number of degrees not immerſed in the fluid by the ſuppoſed difference of heat, dividing the product by 10000, and diminiſhing the quotient by one-eighth part of the whole.

In the following pages we have thrown together the practical rules, which we would recommend to be obſerved in adjuſting the fixed points of thermometers.

Rules to be observed in adjusting the boiling point.

The most accurate way of adjusting the boiling point is, not to dip the thermometer into the water, but to expose it only to the steam, in a vessel closed up in the manner represented in fig. 4. where ABba is the vessel containing the boiling water, Dd the cover, E a chimney made in the cover intended to carry off the steam, and Mm the thermometer passed through a hole in the cover. Those who would make use of this method must take care to attend to the following particulars.

1st, The boling point must be adjusted when the barometer is at 29.8 inches; unless the operator is willing to correct the observed point in the manner directed below.

2dly, The ball of the thermometer must be placed at such a depth within the pot, that the boiling point shall rise very little above the cover; for otherwise part of the quicksilver in the tube will not be heated, and therefore the thermometer will not rise to its proper height. The surface of the water in the pot also should be at least one or two inches below the bottom of the ball; as otherwise the water, when boiling fast, might be apt to touch the ball: but it does not signify how much lower than that the surface of the water may be.

3dly,

3dly, Care muſt be taken to ſtop up the hole in the cover through which the tube is inſerted, and to make the cover fit pretty cloſe, ſo that no air ſhall enter into the pot that way, and that not much ſteam may eſcape. A piece of thin flat tin plate muſt alſo be laid on the mouth of the chimney, ſo as to leave no more paſſage than what is ſufficient to carry off the ſteam. The ſize of this plate ſhould be not much more than ſufficient to cover the chimney, that its weight may not be too great; and the mouth of the chimney ſhould be made flat, that the plate may cover it more completely. It muſt be obſerved, that when the tin plate is laid on the mouth of the chimney, it will commonly be lifted up by the force of the ſteam, and will rattle till it has ſlipped aſide ſufficiently to let the ſteam eſcape without lifting it up. In this caſe it is not neceſſary to put the plate back again, unleſs by accident it has ſlipped aſide more than uſual. If the artiſt pleaſes, he may tie each corner of this plate by a ſtring to prongs fixed to the chimney, and ſtanding on a level with the plate, as thereby it will neceſſarily be kept always in its place(l); but we would by no means recommend having it made with a hinge, as that might

(l) Fig. 3. is a perſpective view of the chimney and tin plate; ABCD is the plate; E the chimney; F*f*, G*g*, M*m*, and N*n*, the prongs faſtened to the chimney, to which the four corners of the plate are to be tied by the ſtrings AF, BG, CM, and DN; the ends F, G, M, and N, of the prongs muſt be on a level with the plate, and the ſtrings ſhould not be ſtretched tight.

be apt to make it ſtick, in which caſe the included vapour might be ſo much compreſſed as to cauſe an error. We would alſo by no means adviſe lining the tin plate with leather, or any other ſoft ſubſtance, for the ſake of making it ſhut cloſer, as that alſo might be apt to make it ſtick. The chimney alſo ought not to be made leſs than half a ſquare inch in area: for though a ſmaller chimney would be ſufficient to carry off the ſteam, unleſs the veſſel is much larger than what we uſed; yet the adheſion which is apt to take place between it and the tin plate when wet, might perhaps bear too great a proportion to the power which the included ſteam has to lift it off, if it was made much leſs. It is convenient that the chimney be not leſs than two or three inches long, as thereby the obſerver will be leſs incommoded by the ſteam; but it would be improper to make it much longer, for the longer the chimney is, the greater diſpoſition has the air to enter into the pot between it and the cover.

It is moſt convenient not to make the cover fit on tight, but to take on and off eaſily; and to wrap ſome ſpun cotton round that part of the cover which enters into the pot, in order to make it ſhut cloſer; or, what ſeems to anſwer rather better, a ring of woollen cloth may be placed under the cover, ſo as to lie between the top

of

of the pot and it. Theſe methods of making the cover ſhut cloſe can be uſed more conveniently when the cover is made to enter within the pot, as in the figure, than when it goes on on the outſide.

There are various eaſy ways by which the hole in the cover, through which the tube of the thermometer is paſſed, may be ſtopped up, and by which the thermometer may be ſuſpended at the proper height. The hole in the cover may be ſtopped up by a cork, which muſt firſt have a hole bored through it, big enough to receive the tube, and be then cut into two, parallel to the length of the hole. Another method, more convenient in uſe, but not ſo eaſily made, is repreſented in fig. 6. which exhibits a perſpective view of the apparatus; A *a* is the cover; H the hole through which the thermometer is paſſed; B *b* a flat piece of braſs fixed upon the cover; and D *d* E *e* a ſliding piece of braſs, made ſo as either to cover the hole H, or to leave it uncovered as in the figure, and to be tightened in either poſition by the ſcrew S ſliding in the ſlit M *m*; a ſemi-circular notch being made in the edge B *b*, and alſo in the edge D *d*, to incloſe the tube of the thermometer: pieces of woollen cloth ſhould alſo be faſtened to the edges B *b* and D *d*, and alſo to the bottom of the ſliding piece D *d* E *e*, unleſs that piece and the cover are made ſufficiently flat, to prevent the eſcape of the ſteam. In

order

order to keep the thermometer suspended at the proper height, a clip may be used like that represented in fig. 7. which by the screw S must be made to embrace the tube tightly, and may rest on the cover. That part of the clip which is intended to bear against the tube, had best be lined with woollen cloth, which will make it stick tighter to the tube, and with less danger of breaking it. Another method, which is rather more convenient, when the top of the tube of the thermometer is bent into a right angle, in the manner frequently practised at present for the sake of more conveniently fixing it to the scale, is represented in the same figure; G*g*F*f* is a plate of brass, standing perpendicularly on the cover, and L*l*N*n* a piece of brass, bent at bottom into the form of a loop, with a notch in it, so as to receive the tube of the thermometer, and to suffer the bent part to rest on the bottom of the loop; this piece must slide in a slit K*k*, cut in the plate L*l*N*n*, and be tightened at any height by the screw T.

4thly, It is best making the water boil pretty briskly, as otherwise the thermometer is apt to be a great while before it acquires its full heat, especially if the vessel is very deep. The observer too should wait at least one or two minutes after the thermometer appears to be stationary, before he concludes that it has acquired its full height.

5thly, Though, as was said before, this appears to be the most accurate way of adjusting the boiling point; yet, if the operator was to suffer the air to have any access to the inside of the vessel, he would be liable to a very great error: for this reason we strongly recommend it to all those who use this method, not to deviate at all from the rules laid down without assuring themselves, by repeated trials with a pretty sensible thermometer, that such alteration may be used with safety. But the covering the chimney with the tin plate ought by no means to be omitted; for though, if the cover of the pot fits close, it seldom signifies whether the plate is laid on or not, yet, if by accident the cover was not to fit close, the omitting the tin plate would make a very great error. Making the chimney very narrow would not answer the end properly; for, if it was made so small as to make the vessel sufficiently close when the water boiled gently, it would not leave sufficient passage for the escape of the steam when the water boiled fast.

Another way of adjusting the boiling point is, to try it in a vessel of the same kind as the former, only with the water rising a little way, namely from one to three or four inches above the ball, taking care that the boiling point shall rise very little above the cover, as in the former method. In this method there is no need to cover the

the chimney with the tin plate; and there is less need to make the cover fit close, only it must be observed, that the closer the cover fits, the less the operator will be incommoded by the steam. The height of the barometer at which the boiling point should be adjusted, when this method is used, is $29\frac{1}{2}$ inches, or three-tenths of an inch less than when the former method is used.

It will be convenient to have two or three pots of different depths; for if a short thermometer is to be adjusted in the same pot which is used for a long one, it will require a great depth of water, which, besides taking up more time before it boils, makes the observation rather less accurate, as the heat seems to be less regular when the depth of water in the pot is very great, than when it is less.

Perhaps some persons, for the sake of heating the water more expeditiously, may be inclined to use an apparatus of such kind that the fire shall be applied to a considerable part of the sides of the pot as well as to the bottom; we would, however, caution them against any thing of that kind, as the observations are considerably less regular than when little more than the bottom of the pot is heated. If the pot is heated over a chafing-dish or common fire, we apprehend that there can seldom be any danger of too much of the sides being heated;

but if the operator ſhould be apprehenſive that there is, it is eaſily prevented by faſtening an iron ring an inch or two broad round the pot near the bottom. This precaution is equally neceſſary when the thermometer is adjuſted in ſteam, eſpecially when there is not much water in the pot.

The greateſt inconvenience of this method of adjuſting the boiling point is the trouble of keeping a proper depth of water in the pot, as to do this it is neceſſary firſt to find the height of the boiling point coarſely by trying it in an open veſſel, and then to put ſuch a quantity of water into the pot that it ſhall riſe from one to three or four inches above the ball, when the thermometer is placed at ſuch a depth within the pot that the boiling point ſhall riſe very little above the cover. The operator muſt be very careful that the quantity of water in the pot be not ſo ſmall as not intirely to cover the ball.

A third way of adjuſting the boiling point is, to wrap ſeveral folds of linen rags or flannel round the tube of the thermometer, and to try it in an open veſſel, taking care to pour boiling water on the rags, in order to keep the quickſilver in the tube as nearly of the heat of boiling water as poſſible. The beſt way is to pour boiling water on the rags three or four times, waiting a few ſeconds between each time, and to wait ſome ſeconds after the laſt

 time

time of pouring on water before the boiling point is marked, in order that the water may recover its full ſtrength of boiling, which is in good meaſure checked by pouring on the boiling water.

In this method the boiling point ſhould be adjuſted when the barometer is at 29.8 inches, that is, the ſame as when the firſt method is uſed; the water ſhould boil faſt, and the thermometer ſhould be held upright, with its ball two or three inches under water, and in that part of the veſſel where the current of water aſcends[(m)].

Whichever of theſe methods of adjuſting the boiling point is uſed, it is not neceſſary to wait till the barometer is at the proper height, provided the operator will take care to correct the obſerved height according to the following table.

(*m*) In a veſſel of boiling water one may almoſt always perceive the current of water to aſcend on one ſide of the veſſel, and to deſcend on the other.

Height

Height of the barometer when the boiling point is adjusted according to,		Correction in 1000ths of the interval between 32° and 212°.		Height of the barometer when the boiling point is adjusted according to,		Correction in 1000ths of the interval between 32° and 212°.	
1st or 3d method.	2d method.			1st or 3d method.	2d method.		
	30.64	10	lower.	29.69	29.39	1	higher.
	53	9		58	28	2	
30.71	41	8		47	17	3	
59	29	7		36	06	4	
48	18	6		25	28.95	5	
37	07	5		14	84	6	
25	29.95	4		03	73	7	
14	84	3		28.92	62	8	
03	73	2		81	51	9	
29.91	61	1		70	—	10	
80	50	0		59	—	11	

To make use of this table, seek the height which the barometer is found to stand at in the left-hand column, if the boiling point is adjusted either in the first or third method, and in the second column if it is adjusted in the second method; the corresponding number in the third column shews how much the point of 212° must be placed above or below the observed point, expressed in thousandth parts of the interval between the boiling and freezing point: for example, suppose the boiling point is

is adjuſted in ſteam when the barometer is at 29 inches, and that the interval between the boiling and freezing points is 11 inches; the neareſt number to 29 in the left-hand column is 29.03, and the correſponding number in the table is 7 higher, and therefore the mark of 212° muſt be placed higher than the obſerved point by $\frac{7}{1000}$ of the interval between boiling and freezing, that is, by $\frac{11 \times 7}{1000}$, or .077 of an inch.

This method of correcting the boiling point is not ſtrictly juſt, unleſs the tube is of an equal bore in all its parts; but the tube is very ſeldom ſo much unequal as to cauſe any ſenſible error, where the whole correction is ſo ſmall. The trouble of making the correction will be abridged by making a diagonal ſcale ſuch as is repreſented in fig. 5.

It is not very material what kind of water is uſed for adjuſting the boiling point, ſo that it is not at all ſalt; only, if any kind of hard water is uſed, it is better that it ſhould be kept boiling for at leaſt ten minutes before it is uſed. But we would adviſe all thoſe deſirous of adjuſting thermometers in the moſt accurate manner for nice experiments, to employ rain or diſtilled water, and to perform the operation in the firſt mentioned manner, that is, in ſteam.

On

On the freezing point.

In adjufting the freezing as well as the boiling point, the quickfilver in the tube ought to be kept of the fame heat as that in the ball. In the generality of thermometers, indeed, the diftance of the freezing point from the ball is fo fmall, that the greateft error which can arife from neglecting this precaution is not very confiderable, unlefs the weather is warmer than ufual; but as the freezing point is frequently placed at a confiderable diftance from the ball, the operator fhould always be careful either to pile the pounded ice to fuch a height above the ball, that the error, which can arife from the quickfilver in the remaining part of the tube not being heated equally with that in the ball, fhall be very fmall; or he muft correct the obferved point, upon that account, according to the following table:

Heat of the air.	Correction.
42°	.00087
52	.00174
62	.00261
72	.00348
82	.00435

The

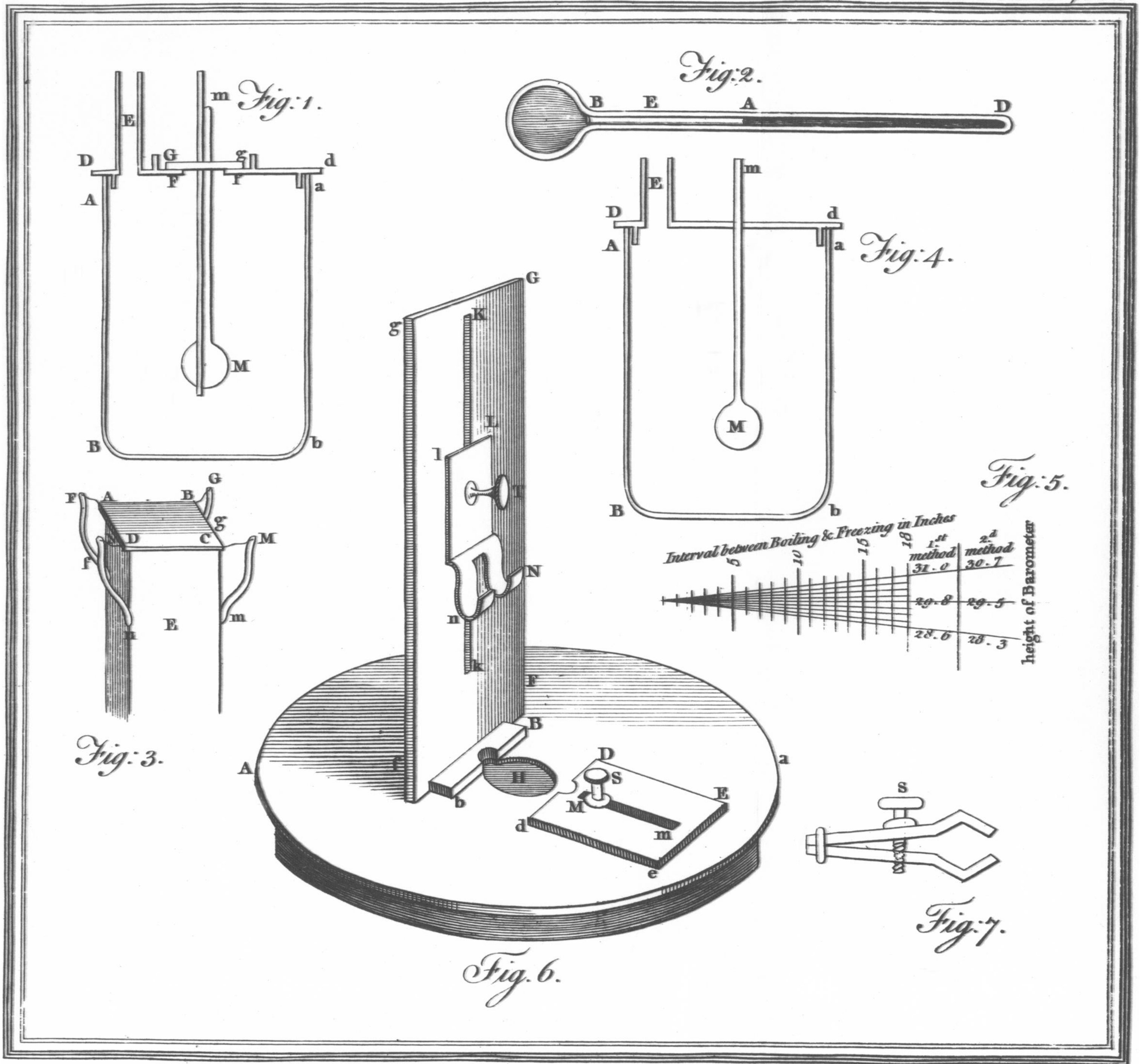
Fig:1.
Fig:2.
Fig:3.
Fig:4.
Fig:5.
Interval between Boiling & Freezing in Inches
5
10
15
18
1.st method
2.d method
31.0
30.7
29.8
29.5
28.6
28.3
height of Barometer
Fig.6.
Fig:7.

Basire Sc.

The first column of this table is the heat of the air, and the second is the correction expressed in 1000th parts of the distance between the freezing point and the surface of the ice: for example, if the freezing point stands seven inches above the surface of the ice, and the heat of the room is 62, the point of 32° should be placed $7 \times .00261$, or .018 of an inch lower than the observed point. This correction also would be made more easy by the help of a diagonal scale, similar to that proposed for the boiling point.

On the precautions necessary to be observed in making observations with thermometers.

In trying the heat of liquors care should be taken that the quicksilver in the tube of the thermometer be heated to the same degree as that in the ball; or, if this cannot be done conveniently, the observed heat should be corrected on that account: but for this we refer to the former part, p. 835.

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